Pre-meeting transect Corsica-Elba Island-Southern Tuscany guidebook. 3- Southern Tuscany. A- Argentario Promontory

3 - SOUTHERN TUSCANY
A - ARGENTARIO PROMONTORY

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Keywords: *field trip, Ligurian-Piedmontese Units, structural geology, petrography, HP/LT metamorphism. Northern Apennines.*

INTRODUCTION

The Argentario Promontory consists of a complex stack of Tuscan, Ligurian and Ligurian-Piedmontese Units (Lazzarotto et al., 1964; Decandia and Lazzarotto, 1980). From bottom to top they are (Fig. 1):

1. **Monticiano-Roccastrada Unit**. It comprises, from bottom to top:

a- ***Mt. Argentario Formation***. Graphitic phyllites with metasiltstone interbeds grading upwards into grey-whitish quartzites and metaconglomerates, with local graphite-rich phyllitic intercalations. This formation has been correlated to the Upper Carboniferous-Lower Permian successions cropping out along the Mid Tuscan Ridge (e.g. the St. Lorenzo Schists of the Pisani Mts. and Iano Schists and Sandstones) and in eastern Elba (Rio Marina Fm.).

b- "***Verrucano".*** Alternating violet and greenish phyllites with local carbonate nodules and levels (caliche), quartzites and quartzitic white-pink metaconglomerates of Late Ladinian?-Carnian age. This succession, which shows an overall fining- and thinning-upward trend (including many metric/decametric positive cycles), is related to continental braided rivers passing upward to a coastal plain environment (Uncini, 1985). In the syntectonic quartz-rich segregations of the "Verrucano" rocks, Theye et al. (1997) found Mg-carpholite which testifies a HP-LT event (P> 8kb T = 300-400°C).

c- ***Tocchi Formation***. It consists of vacuolar, polymictic breccia made up of yellowish carbonatic and grey to green phyllitic clasts. These diagenetic and/or tectonic breccias derive from Carnian siliciclastic-carbonatic lithotypes which constitute the transition from the continental "Verrucano" and the Norian carbonatic shelf deposits.

2. **Tuscan Nappe**. This non-metamorphic unit is constituted by the "Calcare Cavernoso": grey and dark grey, vacuolar calcareous and calcareous-dolomitic breccias with local karst structures. At places, these breccias include boulders and slices of stratified calcareous-dolomitic successions. Cataclastic textures are frequently recognisable.

3. **Cala Piatti Unit**. It is made up of Triassic recrystallised carbonate succession: **a**. Lower?-Middle Triassic stratified grey-pinkish limestones, **b.** Middle-Upper Triassic stratified black limestones, **c**. Upper Triassic? massive or poorly bedded grey dolostones. This succession represents one of the rare evidence of Early?-Middle Triassic marine sedimentation in the Northern Apennines (see also the Punta Bianca-Massa succession: Martini et al., 1986).

4. Cala Grande Unit. It is made up of HP-LT metamorphic rocks. In particular, two lithologic associations are recognisable: **a**. Varicoloured (reddish and grey-green) phyllites with grey and dark grey calcschists and recrystallised limestones; **b**. Metaophiolites (gabbros, basalts, serpentinites and ophiolitic breccias). Particularly, in **b**. HP-LP minerals are present: glaucophanitic amphibole (Mg-riebeckite to crossite)+lawsonite+phengitic mica±Na-pyroxene (Gottardi, 1957; Ricci, 1972; Azzaro et al., 1977; Theye et al., 1997). The presence of Fe-carpholite relics within syn-tectonic quartz veins of the metasedimentary lithotypes (Theye et al., 1997) suggests T= 300-350°C and P>7 kb peak metamorphic conditions in agreement with the Blueschists facies minerals of the Metaophiolites. This unit was correlated to the "Schistes Lustrés" of the Alpine Corsica (Ricci, 1972; Ricci and Serri, 1975).

Polymictic tectonic breccias, mainly made up of elements and slices of "Calcare Cavernoso" and/or "Verrucano" (but locally also of the two uppermost units), separate the Tuscan Nappe from the overlying Cala Piatti Unit and this latter from the Cala Grande Unit.

The complex tectonic stack of Mt. Argentario is related to the Oligo-Miocene compressional stage (which produced the piling up of the "Schistes Lustrés" onto the Tuscan Units and the metamorphism of the Monticiano-Roccastrada Unit), but also to the post-compressional events (Burdigalian-early Tortonian) linked to the extensional tectonics of the Apennines and the Tyrrhenian Sea area (Bartole, 1995; Carmignani et al., 1995, cum bibl.). During the extensional events, the tectonic lamination of the Tuscan Nappe through low-angle normal faults, and the formation of the Mt. Argentario polymictic breccias occurred.

FIELD TRIP

The trip will cross some fine outcrops of the metaophiolites and the metasedimentary successions of the "Schistes Lustrés" (Cala Grande Unit) in the Porto Santo Stefano area, NW of the Argentario Promontory.

The metaophiolites and the metasediments of the Cala Grande Unit ("S*chistes Lustrés*").

The trip moves from Albinia and reaches Porto Santo Stefano. We take the Panoramica road on the northwestern side of the Mt. Argentario Promontory. Here the "Calcare

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Cavernoso" tectonically rests onto the Tocchi Fm. and "Verrucano" (Monticiano-Roccastrada Unit). The polymictic breccias overlying the "Calcare Cavernoso" will be observed along the coastal road. This road crosses also the carbonate rocks of the Cala Piatti Unit and again the polymictic breccias which overlie the metasedimentary rocks of the Cala Grande Unit. Beyond Cala Grande, we arrive in a little parking area in front of the La Ricciatella Isle, where the metaophiolites of the Cala Grande can be examined.

Stop 1. *HP/LT metaophiolites of the Cala Grande Unit.*

These HP-LT metamorphic mafic rocks (Ricci, 1972) and the red-violet metapelites with rare lenses of whitish cherts (Fig. 2), belong to the Cala Grande Unit.

The mafic complex consists of flaser gabbro, coarse and fine grained gabbro and ultramylonitic gabbro. Brecciated textures are also present.

The flaser gabbro (a. in Fig. 2) shows a penetrative planar foliation and a mineralogical lineation of blue amphiboles. Some σ-shaped blue amphibole porphyroblasts indicate a top to NE component of shear (Fig. 3).

The coarse gabbro (b. in Fig. 2), dark-green in colour, is poorly affected by penetrative foliation and conserves its primary structures. Several relics of clinopyroxenes and/or amphiboles are recognisable. This gabbro is cut by several types of veins (f. in Fig. 2) which consists of epidote, or calcite±epidote or quartz±epidote. The fine-grained gabbro (c. in Fig. 2) is recognisable only in the northern part of the outcrop. The ultramylonitic gabbros are fine grained dark-green rocks (e. in Fig. 2). Fig. 4 illustrates the relations between ultramylonitic and undeformed gabbros.

Azzaro et al. (1977) in the mafic rocks reconstructed the following blastesis evolution starting from the magmatic minerals:

a- diallage or augite or brown hornblende → green hornblende or actinolitic-tremolitic amphibole → glaucophanitic amphibole±omphacite (~Jd_{50}) → actinolitic-tremolitic amphibole → chlorite;

b- plagioclase (andesine) → albite+lawsonite → albite+lawsonite+epidote → albite → albite+calcite.

The red-violet metapelites (d. in Fig. 2) are characterised by metapelites and metasiltstones with centimetric lenses of whitish metacherts. The metapelites show a penetrative foliation similar to that observed in the ultramylonitic gabbro. This foliation consists of a greenschist facies mineralogical association (fine grained muscovite+calcite±Mg-chlorite). Reduction spots are rarely recognisable in the upper part of the outcrop.

The trip continues for some hundreds of meters along the road, until the outcrops of the metasedimentary rocks.

Stop 2. M*etasedimentary rocks of the Cala Grande Unit.*

They consist of green-grey and vine red phyllites with centimetric/decimetric intercalations of recrystallised grey limestones. These schistose rocks, which sometimes includes syn- and post-tectonic veins of quartz, are locally affected by folding. In the lower part of the outcrop, an ophiolitic metabreccia (locally replaced by calcite) is present.

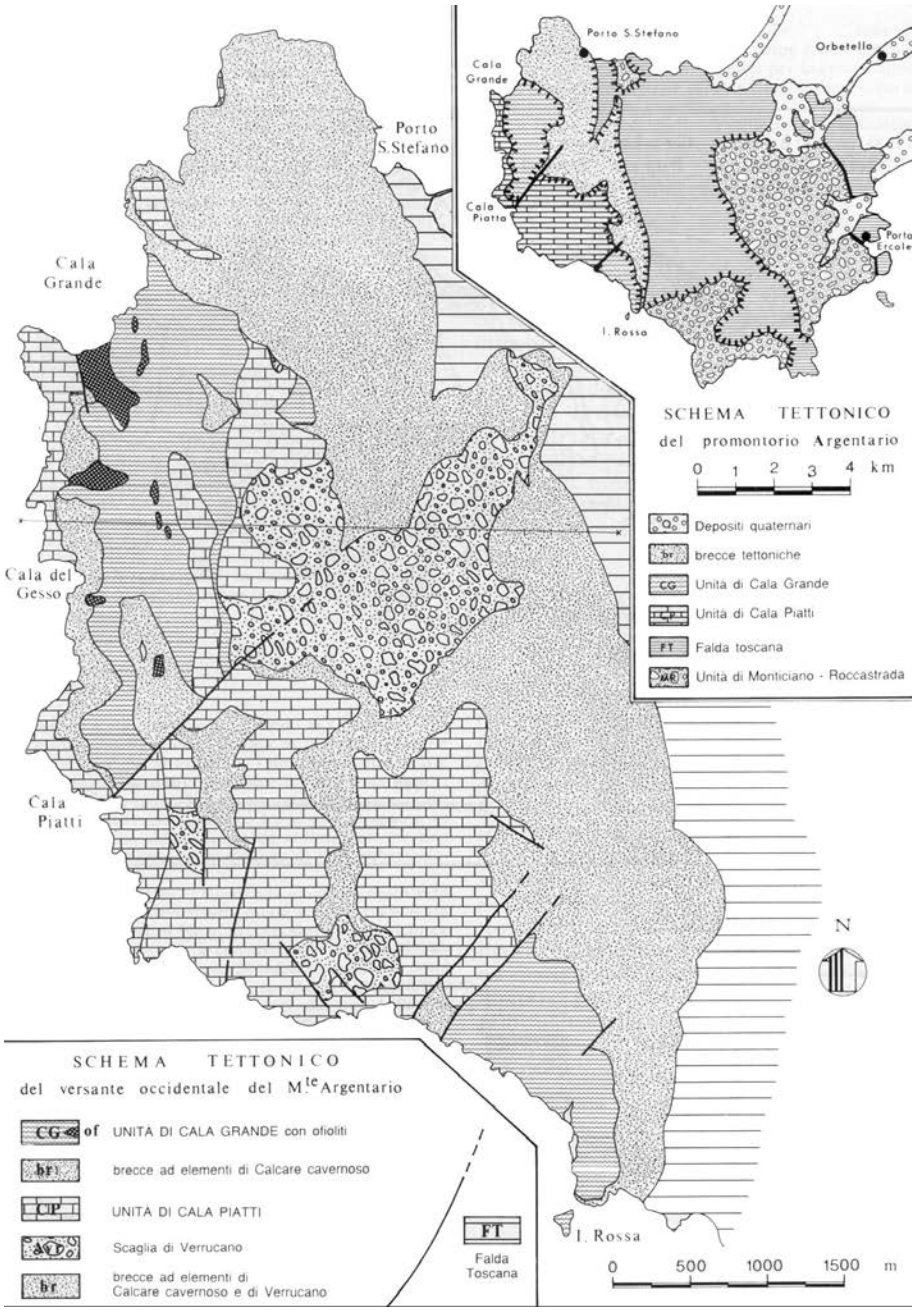

Fig. 1 - Geological sketch map of the Argentario Promontory (after Decandia and Lazzarotto, 1980). Q- Quaternary deposits; br- tectonic breccias; CG- Cala Grande Unit with metaophiolites (of); CP- Cala Piatti Unit; FT- Tuscan Nappe; MR- Monticiano-Roccastrada Unit; vr- "Verrucano" tectonic slices.

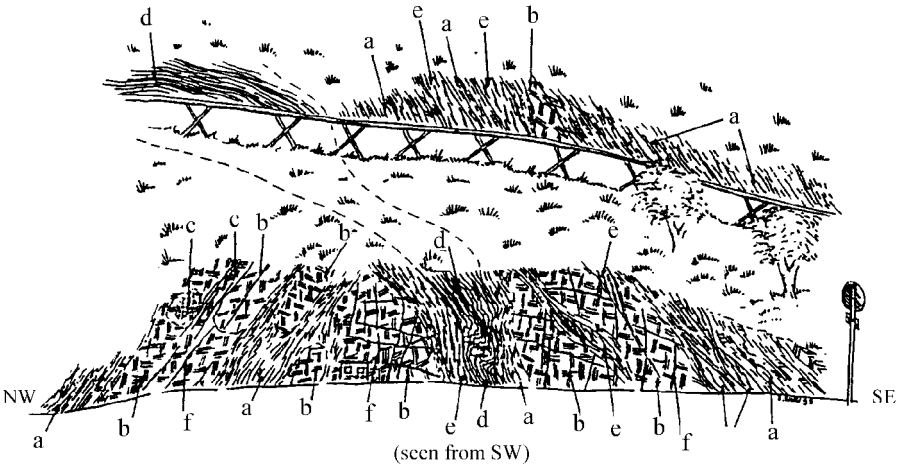

Fig. 2 - Geological sketch of the outcrop (not in scale). For the symbols see text (Stop 1).

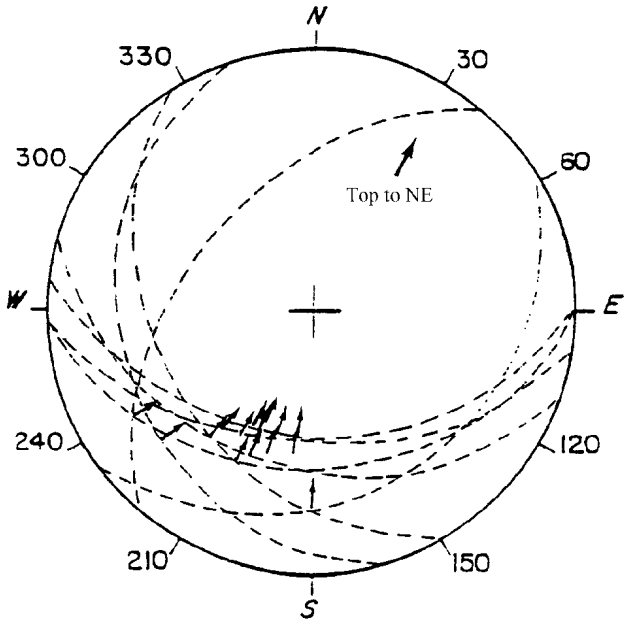

Fig. 3 - Stereonet (lower hemisphere) of the mineralogical lineations made by blue amphiboles.

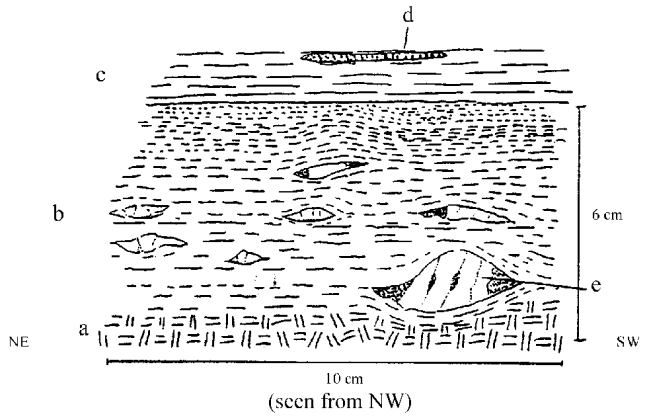

Fig. 4 - Relationships between ultramylonitic and non-deformed gabbros. a- coarse gabbro; b- ultramylonitic gabbro; c- metapelites; d- lenses of whitish cherts; e- clinopyroxene relics with glaucophanitic pressure shadows. A "top to SW" shear component related to the mylonitic foliation is recognisable.

At the microscope. The main schistosity of the phyllitic rocks generally show a lepidoblastic texture made up of Fe,Mg-chlorite+sericite and minor amounts of quartz and albite porphyroblasts (with pressure shadows of chlorite+quartz). Accessory minerals: FeTi-opaques and hematite (abundant in the red lithotypes). In some samples a millimetric grano-lepidoblastic alternance of phyllitic and micaceous microquartzites (recrystallised fine grained quartzarenites or metacherts) is recognisable. Syn-tectonic polycrystalline quartz (±calcite±clorite) ribbons, at times characterised by "mortar"-type structures, are lined up and boudinaged along the main schistosity; small intrafoliar isoclinal rootless hinges are also present. Locally the main schistosity is deformed into close to tight/isoclinal folds whose axial plane schistosity is a millimetric spaced zonal (up to strain-slip) crenulation marked by opaque minerals+sericite alignments. These structures are locally weakly folded. Post-tectonic chlorite, calcite, Fe oxides/hydroxides and Fe-calcite±quartz veins and rare patches of static brown biotite (after chlorite) have been also recognised.

We leave the Mt. Argentario Promontory to Grosseto, where the trip ends

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